EXHIBIT 10

Program
Documentation

BBS CORPORATION

Short Term Capacity Plan

M S D

Metropolitan Sewer District
of Greater Cincinnati
In Conjunction With
BBS Corporation

November 2001
Revised June 2002

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1.0 Introduction

Elimination of Sanitary Sewer Overflows (SSO's) is a high priority for the Metropolitan Sewer District. It will require complex and costly solutions which must be implemented over several years. In the interim, the impact of SSO's on local water quality must be mitigated in anticipation of continued development in tributary areas. Development credits for sewer system rehabilitation are a critical issue to both the Metropolitan Sewer District (MSD) and Ohio Environmental Protection Agency (OEPA). Over the past several years, MSD has committed a significant portion of the annual Capital Improvement Program budget to rehabilitation of the collection system. The incentive to commit these funds is not only to maintain a viable long term infrastructure, but to allow for continued development while improving water quality in Hamilton County. The Short Term Capacity Plan (STCP) provides the basis for how removed infiltration and inflow should be apportioned between allowance for development and improvements to water quality. This document is intended to outline the basis for agreement between MSD of Greater Cincinnati and OEPA for establishing appropriate development credits.

This STCP utilizes the criterion that a minimum five gallons of flow from a downstream SSO is to be removed for every gallon of flow added from a proposed new sewer, sewer extension or flow increase associated with new development upstream of the SSO. Design I/I conditions and estimated peak flows from the new development will be used in evaluating the proposed flow removals and additions.

This STCP Plan may be modified to incorporate new or revised flow figures or methodologies undertaken to remove extraneous water (I/I) from the sanitary sewer system, or to change the removal credit trade ratio. Any such modification to the criteria, formulae, or removal credit trade ratio, set out in the STCP shall be subject to the SCTP modification process defined in Section 5.0 of this STCP Plan.

2.0 Definitions

The following terms are used throughout this document and are listed here with a definition to clarify their use herein.

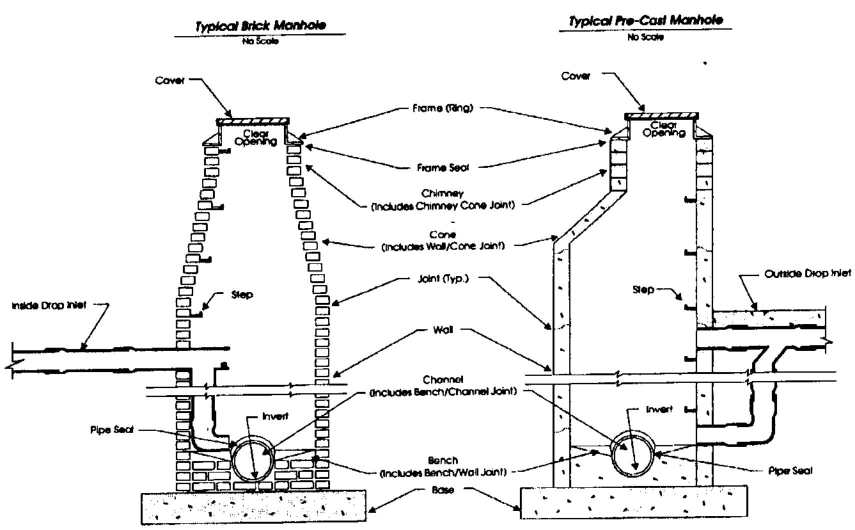
Basin – Sewershed area tributary to an MSD operated wastewater treatment plant.

Combined Sewer System - The portion of the MSD sewer system which conveys municipal sewage (domestic, commercial and industrial wastewaters) and stormwater runoff starting from the point of entry of pipes under public right-of-way through a single pipe system, to the MSD wastewater treatment plants.

ERC - The Equivalent Residential Connections available for trading based upon 400 gallons per day per single family residence. The trade ratio used is also factored in. As an example, 12,000 gpd of I/I removed with a trade ratio of 5:1 would equate to 6 ERC based on the following equation:

$$\frac{\text{12,000gpd removed}}{\text{400 gpd/residence x 5 gpd removed per gallon added}}$$

Manhole - Access points along the sewer system. Parts of the manhole referred to in this document are as follows:



Basic Manhole Components

Infiltration - the water entering a sewer system and service connections from the ground through such means as, but not limited to, pipes, pipe joints, connections, manhole walls or manhole joints.

Inflow - The water discharged into a sewer system, including service connections, from such sources as, but not limited to; roof leaders; cellars, yard and area drains; foundation drains; cooling water discharges; drains from springs and swampy areas; manhole covers; cross connections from storm sewers; surface runoff; street wash waters; or drainage.

I/I - The total quantity of water from both infiltration and inflow without distinguishing the source.

Residential Flow - The average daily flow contribution from a single family residence based on 4 persons per home and 100 gallons per day per person.

Riparian Area - The area immediately adjacent to streams. The width is determined by 2-1/2 times the stream width as measured from bank to bank during normal dry weather flow. The limits of the riparian zone shall be 2-1/2 times the stream width measured on each side of the stream centerline. Exceptions will be made where topography dictates a larger or smaller riparian area when sufficient documentation is provided. Documentation may include stream cross-sections or photographs of the area.

Sanitary Sewer Overflow or SSO - Any discharge to waters of the State or United States from MSD's sanitary sewer system through known point sources.

Sanitary Sewer System - All portions of MSD's sewer system that are not a part of the combined sewer system.

Sewer Inch-Mile - Term referring to sewer lines arrived at by multiplying the sewer diameter by the length in miles. Thus 1,500 feet of 12-inch sewer would be 1,500 / 5,280 x 12 = 3.4 in-mi.

Sewer Rehabilitation – Lining, sealing or grouting of a sewer line intended to improve the structural integrity of the sewer line and/or eliminate I/I from entering the system.

SSO Sewershed - The drainage basin above and contributing to an SSO.

SRP Program - Stormwater Removal Program initiated by the District in 1992 that reimburses homeowners for removing sources of I/I from the sanitary sewer including downspouts, driveway drains, area drains and stairwell drains.

Trade Ratio - The ratio of gallons of I/I removed from the system to additional gallons allowed for new development. The ratio is affected by both the confidence in the volume of I/I removed as well as the desire to improve water quality.

3.0 Credits Program

The credits program includes credits given for new development based on the following types of sewer system rehabilitation:

- Removal of downspout and/or driveway drain connections.
- Rehabilitation of deteriorated sewer lines.
- Rehabilitation of deteriorated manholes.

The credits in this STCP area a result of industry accepted numbers that have been modified based on a verification program performed by the District. The following are the resulting credits that have been negotiated with Ohio EPA.

3.1 Approved Credits

Credits are expressed in ERC units (equivalent residential connections). ERCs are calculated based on 1,600 gallons per day peak residential flow per single family residence and a 5:1 trade ratio between gallons of flow removed and new flow from proposed developments.

3.1.1 Downspout and Driveway Drain Removals

Credits for downspouts and driveway drains are as follows:

Downspouts	2 ERCs per downspout
Driveway drains	3 ERCs per driveway drain

3.1.2 Rehabilitation of Deteriorated Mainline Sewers

Credits for mainline sewer rehabilitation or replacement are as follows:

Riparian Areas	17 ERCs per inch-mile of rehabilitated pipe
Non-riparian Areas	.03 ERCs per inch-mile of rehabilitated pipe

3.1.3 Manhole Rehabilitation

Credits for manhole rehabilitation are divided into two categories, replacement of vented manhole lids and repair of manhole defects.

3.1.3.1 Replacement of Vented Manhole Lids

Replacement of vented manhole lids shall be with either the new modified solid lids (with only two pick holes), solid lids, or dish inserts. An interim approval of up to 200 ERCs per basin through the year 2003 is agreed upon herein. A review of this limit and the methodology for verification of values will be conducted by MSD and OEPA in accordance with Section 5. Credits for lid replacements or inserts will only be allowed for manholes that are in the riparian areas if installed prior to September 29, 1982.

Credits given are dependent upon their location and their susceptibility to inundation by rainwater during wet weather conditions. These are defined as follows:

- **1-inch Inundation** – Manholes will be considered to be subject to a 1" inundation when the top of casting is within two feet of the normal dry weather pool stage in the upper half of the basin or within four feet of the pool stage in the lower half of the basin.

- **1/8-inch Inundation** – Manholes in paved areas that completely lie within a distance of the curb no more than 1/4 of the width of the street as measured from curb to curb will be considered "1/8-inch inundation". Note that the street must have a formed curb to be considered for this category.

- **Splash** – Manholes in paved areas that lie outside the area defined in 1/8" inundation above or manholes in non-paved areas that are flush with the ground are considered "splash". Any manholes in paved areas where there is no formed curb will be considered as "splash".

- **Non-paved, Non-Riparian** – Manholes in these non-paved areas will be approved for credits on a case-by-case basis. Documentation of field conditions will be provided to OEPA for approval to include: actual topographic information, other supportive drainage calculations, or photographs showing the potential for over land inflow.

Credits given for vented manhole lid replacement are:

Splash	1/8-inch	1-inch
1 ERC	4 ERC	20 ERC

3.1.3.2 Repair of Manhole Defects

The second category for manhole credits is the rehabilitation of specific defects in the manhole structure. These defects will be logged on an inspection form as found in Appendix B. Credits are determined by severity and number of defects as logged as well as the location of the manhole. American Society of Civil Engineers, Manual of Practice No. 92 was used as the basis of classification with values adjusted to reflect actual field testing done to date. The credits tables on the following pages outline credits given for paved areas, riparian areas and non-riparian areas.

3.1.4 Foundation Drain Credits

Removal of foundation drain sump pumps from the sanitary sewer system are credited at 2 ERC per sump pump.

3.2 Credits Tracking

The District has been tracking credits earned from SRP corrections, sewer replacement and sewer rehabilitation. A running log is maintained, tracking available credits based on credits earned and used within each SSO sewershed. This tracking has been expanded to include credits earned through manhole rehabilitation and sump pump removals. This tracking report will be submitted to OEPA on a quarterly basis to update the status of the credits program.

The effective-retroactive date for credit claims is January 1, 2000.

Current Credit Table

Manholes in Riparian Areas

Credits Ratio 5:1

	Minor I/I			Moderate I/I			Heavy I/I			Severe I/I		
	gpm	gpd*	erc**	gpm	gpd*	erc**	gpm	gpd*	erc**	gpm	gpd*	erc**
Frame seal	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7	4.8	6,912	3.5
Chimney	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7	4.8	6,912	3.5
Cone	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7	4.8	6,912	3.5
Wall	0.3	432	0.2	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7
Pipe Seal	0.3	432	0.2	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7
Bench	0.3	432	0.2	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7
Channel	0.3	432	0.2	0.6	864	0.4	1.2	1,728	0.9	2.4	3,456	1.7

* gpd calculated based on gpm x 60 min/hr x 24 hr/day

** erc represents equivalent residential connections based on 400 gal/day/residence

Reserve the right to test a manhole to determine credits on a 5:1 ratio using infiltration method

Current Credit Table

Manholes in Non-riparian Areas

Credits Ratio 5:1

	Minor I/I			Moderate I/I			Heavy I/I			Severe I/I		
	gpm	gpd*	erc**	gpm	gpd*	erc**	gpm	gpd*	erc**	gpm	gpd*	erc**
Frame seal	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7	1.8	2,627	1.3
Chimney	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7	1.8	2,627	1.3
Cone	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7	1.8	2,627	1.3
Wall	0.1	164	0.1	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7
Pipe Seal	0.1	164	0.1	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7
Bench	0.1	164	0.1	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7
Channel	0.1	164	0.1	0.2	328	0.2	0.5	657	0.3	0.9	1,313	0.7

* gpd calculated based on gpm x 60 min/hr x 24 hr/day

** erc represents equivalent residential connections based on 400 gal/day/residence

Reserve the right to test a manhole to determine credits on a 5:1 ratio using infiltration method

Current Credit Table

Manholes in Paved Areas

Credits Ratio 5:1

	Minor I/I			Moderate I/I			Heavy I/I			Severe I/I		
	gpm	gpd*	erc**	gpm	gpd*	erc**	gpm	gpd*	erc**	gpm	gpd*	erc**
Frame seal	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2	0.4	622	0.3
Chimney	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2	0.4	622	0.3
Cone	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2	0.4	622	0.3
Wall	0.0	39	0.0	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2
Pipe Seal	0.0	39	0.0	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2
Bench	0.0	39	0.0	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2
Channel	0.0	39	0.0	0.1	78	0.0	0.1	156	0.1	0.2	311	0.2

* gpd calculated based on gpm x 60 min/hr x 24 hr/day

** erc represents equivalent residential connections based on 400 gal/day/residence

Reserve the right to test a manhole to determine credits on a 5:1 ratio using infiltration method

4.0 Credit Verification Program

The Credits Verification Program is a field program intended to quantify actual I/I removal rates for various types of manhole and sewer system rehabilitation. These program results will be used to adjust the credits program values where applicable. Modifications to credit values will be done in accordance with Section 5.0.

The Credits Verification Program consists of two parts. The first is to verify credits given for manhole rehabilitation work. This part of the program is currently underway. The second is to verify credits given for main line rehabilitation and replacement work.

4.1 Manhole Testing *(revised 6/2002)*

Manholes are currently being tested in three types of locations:

- Riparian areas
- Non-riparian areas paved
- Non-riparian areas not paved.

A total of fifteen manholes will be tested in each location type. No more than five will be on any single sewer line. This will ensure that an average manhole condition is tested. Manholes are being selected based on manhole inspection reports that have been completed as a part of other projects.

The testing procedure for each manhole shall be as follows:

1. Rinse manhole and spray with disinfectant. Plug the influent and effluent lines in the manhole with flow-through plugs to isolate the manhole from the sewer line. The use of flow-through plugs allows the flow of sewage to continue during the testing procedure to eliminate the possibility of sewage back-ups during the test.

2. Fill the manhole to the top of casting and maintain this level for a period of at least 30 minutes. This is to allow exfiltration out of the manhole to fill the voids in the soil surrounding the manhole in dry periods in order to simulate a high groundwater condition.

3. Pump the water from the manhole and begin recording the infiltration rate.

4. For a period of one hour, infiltration entering the manhole is pumped out of the manhole and the volume recorded along with the time. Infiltration rate will be measured in 15 unit increments.

5. The total volume removed from the manhole over the testing period is the infiltration rate the manhole experiences during high groundwater conditions. This rate can then be converted to a gallon per day rate.

Final credits will then be determined from the results from each location type and applying the trade ratio agreed upon by OEPA. The District shall submit the results of the testing program to OEPA by October 1, 2003. Based on the test results, the District may propose a change in the allowable credits for manhole rehabilitation. Any such change shall be made in accordance with Paragraph 5.0.

4.2 Mainline Sewer Rehabilitation Testing *(revised 6/2002)*

Credits for mainline sewer rehabilitation in riparian and non-riparian zones will be evaluated over the next several months. Pre and post-rehabilitation flow monitoring will be conducted over a sufficient time to provide confidence in the credit calculations. An attempt will be made to isolate parts of the system to assure that credits are determined only for the mainline rehabilitation/replacement.

By October 1, 2002, the District shall submit a plan and expeditious schedule to Ohio EPA to evaluate credits for mainline sewer rehabilitation/replacement in riparian and non-riparian zones. Upon approval, the District shall implement the plan in accordance with the approved schedule. Based on the results of the evaluation, the District may propose a change in the allowable credits for mainline sewer rehabilitation/replacement. Any such change shall be made in accordance with Paragraph 5.0.

4.3. Sewer Rehabilitation Test Area *(added 6/2002)*

An area, described as the Brill Road Test Area, will have manhole rehabilitation and mainline rehabilitation performed followed by flow monitoring in an effort to quantify the amount of infiltration and inflow removed from the sewer system. This area will be the first of an ongoing series of test areas used to better define removal of extraneous flow from the system. The following schedule outlines the estimated time frames to complete the rehabilitation and analysis.

Completion of Manhole Rehabilitation:	12/31/01
Completion of Manhole Rehabilitation flow monitoring and analysis:	12/31/02
Legislation requested for sewer rehabilitation funding:	6/30/03
Sewer Rehabilitation Completed:	6/30/04
Post flow monitoring completed:	6/30/05
Summary report Completed:	12/31/05

The dates in the above schedule may be modified with the written approval of both the Ohio EPA and the Director of the District. In order to modify any date the Director of the District shall, at least 45 days in advance of the deadline date in question, submit the revised date(s) to Ohio EPA for its approval. If a schedule modification is approved by Ohio EPA in writing, the District shall implement the remainder of the work in accordance with the approved schedule modification.

5.0 STCP Modifications

In a sewer system as large as that in Hamilton County, there are always some situations that cannot be represented by an average condition. In areas where severe deterioration has occurred, the District reserves the option of specific testing of either manholes or sewer lines to determine the actual I/I rate that will be removed by rehabilitation or replacement work. Where this site specific testing is performed, credits would be given based on the test results applied using the agreed upon trade ratio. This allows the District to receive a fair credit for these exceptional areas and still provide the positive impact on the environment.

The approval of credits in these extreme circumstances will be subject to an approval process by OEPA as described below.

In addition, future field tests or better documentation may result in the modification of the credits as set forth in this document. The interim removal credits for downspouts, driveway drains, sewer replacement/rehabilitation, and/or manhole rehabilitation as set forth above in Section 3.0 Credits Program, may be modified based on new or revised flow information. This data shall be documented as part of the credit verification program implemented pursuant to Section 4.0, provided that any such changes, together with the quantified supporting data, are submitted to Ohio EPA for review and receive written approval from Ohio EPA. Upon Ohio EPA approval of such modifications, the existing STCP shall be modified by MSD consistent with Ohio EPA's approval.

The STCP may be modified by the addition of removal credits from other sources of excessive infiltration/inflow as a result of the development of adequate flow figures and/or equations to properly reflect the impact from such projects in terms of a removal credit. In the event that such removal credit(s) are proposed to be added to the credits program MSD shall submit the proposed credits, together with the supporting data, and the proposed modifications to the credit verification program to Ohio EPA for review. Upon Ohio EPA approval of such modifications the existing STCP shall be modified by MSD consistent with Ohio EPA's approval.

ATTACHMENT A

Detailed Criteria of I/I Rate Given for Each Defect

Table 5.2 from ASCE Manual of Engineering Practice No. 92

Component	Rating/description/default flow (gpm)				
	No I/I 1	Minor I/I 2	Moderate I/I 3	Heavy I/I 4	Severe I/I 5
Cover (1)	No evidence	Pick or other unsealed cover. No ponding.	Corroded bearing surface. No ponding.	Ponding < 1" with pick or other unsealed cover.	Ponding > 2" pick or other unsealed cover.
Frame seal	0.0 No evidence	0.2 Water marks	0.4 Some soil present at cracks	0.8 Heavy soil/roots/ 1/8" gap in drainage area.	≥1.6 ≥1.8" gap in drainage area.
Chimney	0.0 No evidence.	0.2 Water marks. 1 location	0.4 Water marks. 2-3 locations or mineral deposits. Joint leak (<10%).	0.8 Multi water marks. Mineral deposits. Joint leak (<25%)	≥1.6 Multi water marks. Mineral deposits. Drainage area. Joint leak (>25%).
Cone	0.0 No evidence.	0.2 Water marks. 1-2 locations.	0.4 Water marks. 3-4 locations or mineral deposits. Joint leak (10%).	0.8 Multi water marks or mineral deposits. Joint leak (25%).	≥1.6 Multi water works. Mineral deposits or soil present. Join leak (>25%).
Wall	0.0 No evidence.	0.1 Water marks. 1-2 locations.	0.2 Water marks. 3-4 locations or mineral deposits. Joint leak (10%).	0.4 Multi water marks or mineral deposits. Joint leak (25%).	≥0.8 Multi water marks. Mineral deposit or soil present. Joint leak (>25%).
Pipe seal	0.0 No evidence.	0.1 Water marks. 1-2 locations.	0.2 Water marks. 3-4 locations or mineral deposits. Soil leak (10%).	0.4 Multi water marks or mineral deposits. Seal leak (25%).	≥0.8 Multi water marks. Mineral deposit or soil present. Soil leak (>25%).
Bench	0.0 No evidence	0.1 Water marks. 1-2 locations.	0.2 Water marks. 3-4 locations or mineral deposits. Joint leak (10%).	0.4 Multi water marks or mineral deposits. Joint leak (25%).	≥0.8 Multi water marks. Mineral deposit or soil present. Joint leak (>25%).
Channel	0.0 No evidence.	0.1 Water marks. Hairline crack beneath flow.	0.2 Water marks. Mineral deposits or 1/18" crack beneath flow.	0.4 Water marks and mineral deposits. 1/8" crack beneath flow.	≥0.8 Mineral deposits. Soil. 1/4" crack beneath flow.

NOTE: "%" refers to the percentage of circumference that contains the indicated observation.
(1) No default cover inflow provided since inflow depends on type of cover, condition of cover, and ponding depth. Calculate leakage using manufacturer's data or appropriate orifice equations for pick holes.

ATTACHMENT B

Manhole Inspection Form

MANHOLE INSPECTION FORM

Inspection Date: ______________________ Inspector: ______________________

Manhole No.: ______________________ Location ______________________

Sewershed: ______________________ Depth: ______________________

General

***Status*:**
- ◯ Surface inspected
- ◯ Internal inspected
- ◯ Not found
- ◯ Buried

Location:
- ◯ Paved
- ◯ Non-paved
- ◯ Stream Areas

Structure Type:
- ◯ Manhole
- ◯ Flush Hole
- ◯ Siphon Box
- ◯ Junction Box
- ◯ Other __________.

Ground Condition:
- ◯ Dry
- ◯ Moderate
- ◯ Wet

Cover

Standard:
- ◯ Vented
- ◯ Vented-bolted
- ◯ Solid
- ◯ Solid-bolted #
- ◯ None

***Nonstandard*:**
- ◯ Other

Fit:
- ◯ Good
- ◯ Tight
- ◯ Loose
- ◯ Rocking
- ◯ Cracked

Condition:
- ◯ Good
- ◯ No Gasket
- ◯ No Bolts
- ◯ Corroded/Pitted

No. of Holes:
- ◯ None
- ◯ Pick (1)
- ◯ Pick (2)
- ◯ 3- - 5
- ◯ 6 – 8
- ◯ > 8

Susceptibility to Flood:
- ◯ None
- ◯ Splash
- ◯ 1/8"
- ◯ 1" or greater

Cover No. / Type: [ ]

Casting

Size (In): [ ] / [ ] / [ ]

Cir.Opn'G / Cover Opn'G / Frame Depth

Offset (In): [ ]

Condition:
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Deteriorated

Casting Seal

Condition:
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Deteriorated

Inflow:
- ◯ None
- ◯ Low
- ◯ Moderate
- ◯ Heavy
- ◯ Severe

Chimney

Depth (In): [ ]

Min. Dia. (In): [ ]

Const.:
- ◯ None
- ◯ Precast
- ◯ Brick
- ◯ Block
- ◯ Poured
- ◯ Other

Condition:
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Deteriorated

Observed Flow:
- ◯ None
- ◯ Low
- ◯ Moderate
- ◯ Heavy
- ◯ Severe

Cone

Shape:	Const:	Condition:	Inflow:	Defect Location:	Defect Quantity:
◯ Concentric	◯ None	◯ Good	◯ None	◯ Wall/Cone Joint	◯ 1
◯ Eccentric	◯ Precast	◯ Fair	◯ Low	◯ Cone Surface	◯ 2
◯ Flat Top	◯ Brick	◯ Poor	◯ Moderate	◯ Chimney & Cone	◯ 3
◯ Other	◯ Block	◯ Deteriorated	◯ Heavy		◯ 4
	◯ Poured		◯ Severe		◯ > 4
	◯ Other				

Wall

Minimum Dimensions (In): ____ *x* ____ ***Bottom Dia. (In):*** ____

Const:	Condition:	Infiltration:	Defect Location:	Defect Quantity:
◯ None	◯ Good	◯ None	◯ Wall Joint	◯ 1
◯ Precast	◯ Fair	◯ Low	◯ Top Half	◯ 2
◯ Brick	◯ Poor	◯ Moderate	◯ Bottom Half	◯ 3
◯ Block	◯ Deteriorated	◯ Heavy	◯ Entire Depth	◯ 4
◯ Poured		◯ Severe		◯ > 4
◯ Other				

Bench

Const:	Condition:		Infiltration:
◯ None	◯ Good		◯ None
◯ Precast	◯ Fair		◯ Low
◯ Brick	◯ Poor	◯ Moderate	
◯ Block	◯ Deteriorated		◯ Heavy
◯ Poured			◯ Severe
◯ Other			

Channel

Const:	Condition:	Infiltration:	Hydraulics:
◯ None	◯ Good	◯ None	◯ Good
◯ Precast	◯ Fair	◯ Low	◯ Fair
◯ Poured	◯ Poor	◯ Moderate	◯ Poor
◯ VCP	◯ Deteriorated	◯ Heavy	◯ Deteriorated
◯ Plastic		◯ Severe	
◯ Other			

Step

Const:	Condition:
◯ None	◯ Good
◯ Bar	◯ Fair
◯ Iron	◯ Poor
◯ Plastic	◯ Deteriorated
◯ Other	

Surcharge Evidence (ft): ____

Note 1 (Overflow Yes/No): ____

Note 2: ____

Memo

Notes:

ATTACHMENT C

Neenah Foundry Company's "A Report On Inflow Of Surface Water Through Manhole Covers"

A REPORT

NEENAH

NEENAH

TABLE OF CONTENTS

INTRODUCTION

With the current awareness of the ecological ramifications of water pollution, much effort and money is being directed towards the cost of effective upgrading of wastewater treatment facilities and distribution systems throughout the nation. This upgrading not only deals with requirements for higher levels of treatment for daily wastewater flows at treatment facilities, but is also directed at the reduction and eventual elimination of in-system bypassing of wastewater. This bypassing is largely a result of the intrusion of surface runoff waters and/or groundwater into sewer systems during wet weather periods of the year.

This joint report by Neenah Foundry Co. and staff members of American Consulting Services of Minneapolis, Minn. is an outgrowth of investigations conducted as part of one particular phase of the construction grants program, namely the Sewer System Evaluation Survey (SSES). As defined in the federal government's Title 40 Rules and Regulations, a Sewer System Evaluation Survey . . . "consists of a systematic examination of the sewer system to determine the specific location, estimated flow rate, method of rehabilitation and cost of rehabilitation versus cost of transportation and treatment for each defined course of infiltration/inflow". (1)

PURPOSE

With the investigations conducted in the field according to the SSES Program, one of the most common and costly sources of inflow identified in most of today's sewer systems, is manhole lids subject to surface runoff inflow. (See Figure 1 and other examples, Appendix B). There has been a general absence of information as to how much surface water could inflow into a system through manhole lids. It was this need that provided the stimulus for this report with the hope that some simple, effective method of rehabilitation could be designed.

This report, in particular, investigates:

(1) Quantities of surface runoff which enter the sewer system through different sized manhole lids.

(2) How surface runoff, manhole lid bearing surface, and pickhole and vent hole area affect the quantity of inflow through these lids.

(3) An effective, relatively inexpensive, alternative for the elimination of this source of inflow into the sewer system.

It is hoped that the information contained in this report will help to enlighten municipalities, their consultants and respective state or federal agencies to the magnitude of this problem and to the alternative available for its solution.

Figure 1
Inflow Through Manhole Lid

1. Infiltration/Inflow — *See* Definitions, **Appendix A**

APPARATUS

To conduct the tests a large cylindrical flooding tank was constructed. (See Figure 2). The tank had an inside diameter of 39½" was 15" deep and equipped with a 3" diameter outlet pipe which protruded from the bottom center of the tank. A rubber coated wooden plug was used as the stopper for this outlet. The tank was supported about 3 feet above the floor by four legs to accommodate an 18" x 36" x 15" deep receiving tank. To facilitate measurement of the inflow water collected in the tank after each trial, the receiving tank was equipped with casters which allowed it to be rolled out from under the flooding tank.

The manhole frames were bolted to the bottom of the test tank, using a flat rubber gasket as a seal, This provided a watertight joint between the tank and manhole frame, Water would then be introduced into the flooding tank by hose, filling it to the desired head.

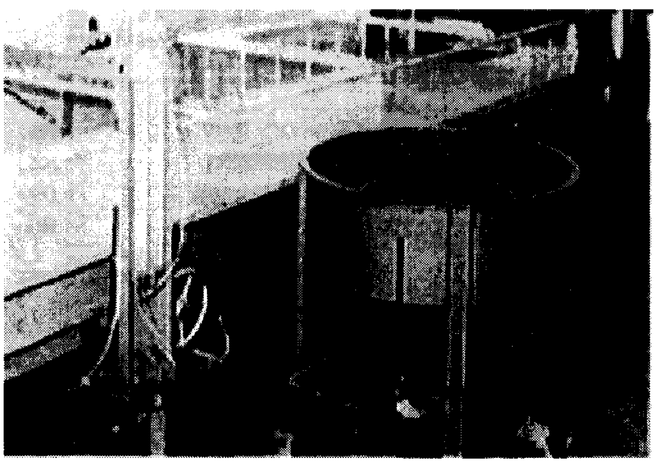


Figure 2
Flooding Tank

PROCEDURES

With the receiving tank empty and the outlet plugged, the test could begin at the time water began to flow through the top of the manhole cover. Duration of the test was one minute by stop watch and the water was allowed to flow into the receiving tank below. After one minute the outlet was plugged so no additional water could enter the receiving tank. The water collected in the receiving tank was then measured with a point gauge and recorded as the amount of inflow that the particular manhole lid would allow to enter during the one minute time period.

There are basically two locations in manhole lids through which surface runnoff can enter the manhole lid. One is by direct passage through open pick and vent holes, and the other is by seepage through the manhole lid and frame contact (bearing) surface along the perimeter of the manhole frame and lid. All of these sources would be affected directly by increased water head. In addition, the bearing surface itself will permit varying amounts of inflow depending on the quality of the seating surfaces and whether that surface is ground or commercially machined.

In order to more closely evaluate what part of the total manhole inflow can be associated with the bearing surface and vent and pickhole areas, the testing was set up to test each source separately.

To test for bearing surface inflow, solid manhole covers containing concealed pickholes were used. Five different sized manhole cover assemblies detailed in Appendix C and ranging in size from 22" to 26" in diameter were tested, first with a ground bearing surface and then these same sizes were again tested with a machined finish bearing surface. To overcome the variations expected from one set of castings to another, a total of 136 different casting sets were randomly selected from the Neenah Foundry stock. Over 2000 individual tests were conducted and averaged into 441 categorized separate data points, reproduced in Appendix D of this report.

To test for pickhole and venthole inflow, manhole lids were sealed to the frames to make watertight bearing surfaces. Each lid contained one hole either ¾", 1", 1¼", 1½", or 2" in diameter. Ten trials were run for each hole diameter to determine average values for plotting as shown in Appendix E.

Three water head conditions were simulated for each lid to reflect basic runoff situations for both bearing surface and vent and pick hole tests.

They are:

Test 1: Splashing water on lid simulating steady rainfall with no ponding.

Test 2: Water on cover allowed to accumulate to 1/8" head.

Test 3: Runoff simulation allowed to pond to a 1" head.

No attempt was made to introduce dirt, debris, sand or silt into the clear water or manhole lid and frame bearing surfaces and holes.

RESULTS

A. Bearing Surface Inflow

The results of the bearing surface inflow tests are summarized in the following tables 1 and 2, and are graphically presented in figures 3 through 7.

Table 1
Non-Machined Bearing Surface Inflow

Manhole Type	Diameter Inches	Test 1 Avg. GPM	Test 1 Std. Dev.	Test 2 Avg. GPM	Test 2 Std. Dev.	Test 3 Avg. GPM	Test 3 Std. Dev.
R-1090	22	3.88	1.10	9.81	2.12	15.99	3.74
R-1040	23	2.20	1.00	7.76	4.15	14.80	6.02
R-1670	24	3.97	1.21	12.08	2.34	17.34	3.88
R-1760	25	6.26	1.53	12.89	3.11	18.57	4.06
R-1642	26	3.65	1.14	10.62	3.79	17.29	5.57
Avg.		3.99		10.63		16.80	

Table 2
Machined Bearing Surface Inflow

Manhole Type	Diameter Inches	Test 1 Avg. GPM	Test 1 Std. Dev.	Test 2 Avg. GPM	Test 2 Std. Dev.	Test 3 Avg. GPM	Test 3 Std. Dev.
R-1090	22	.99	·37	1.27	.43	1.87	.56
R-1040	23	.82	.30	1.60	.99	2.27	1.67
R-1670	24	.93	.42	2.00	.54	2.81	.84
R-1760	25	1.43	.36	2.29	.70	3.23	1.02
R-1642	26	1.14	.50	1.87	.79	2.52	.96
Avg.		1.06		1.81		2.54	

The effect of machined bearing surfaces on the reduction of bearing surface inflow is very graphically pictured in figures 3 through 7. As the standard deviation computations reveal, individual manhole frame and lid combinations within the same manhole type and test condition can differ significantly in the amount of inflow they will allow.

B. Venthole and Pickhole Inflow

Figure 8, page 9 portrays the results of the pickhole/venthole tests conducted on ¾", 1", 1¼", 1½" and 2" diameter pick/vent holes. As might be anticipated, the results for all three of the test conditions closely approximate a straight line relationship between water head, hole area, and inflow received. The slopes of these curves are as follows:

Test	Inflow (GPM/in.^{2})
1	0.25
2	1.00
3	4.94

FIGURE 3

R1090 WITH CONCEALED PICK HOLES, LID DIAMETER 22"

INFLOW THROUGH BEARING SURFACES ONLY

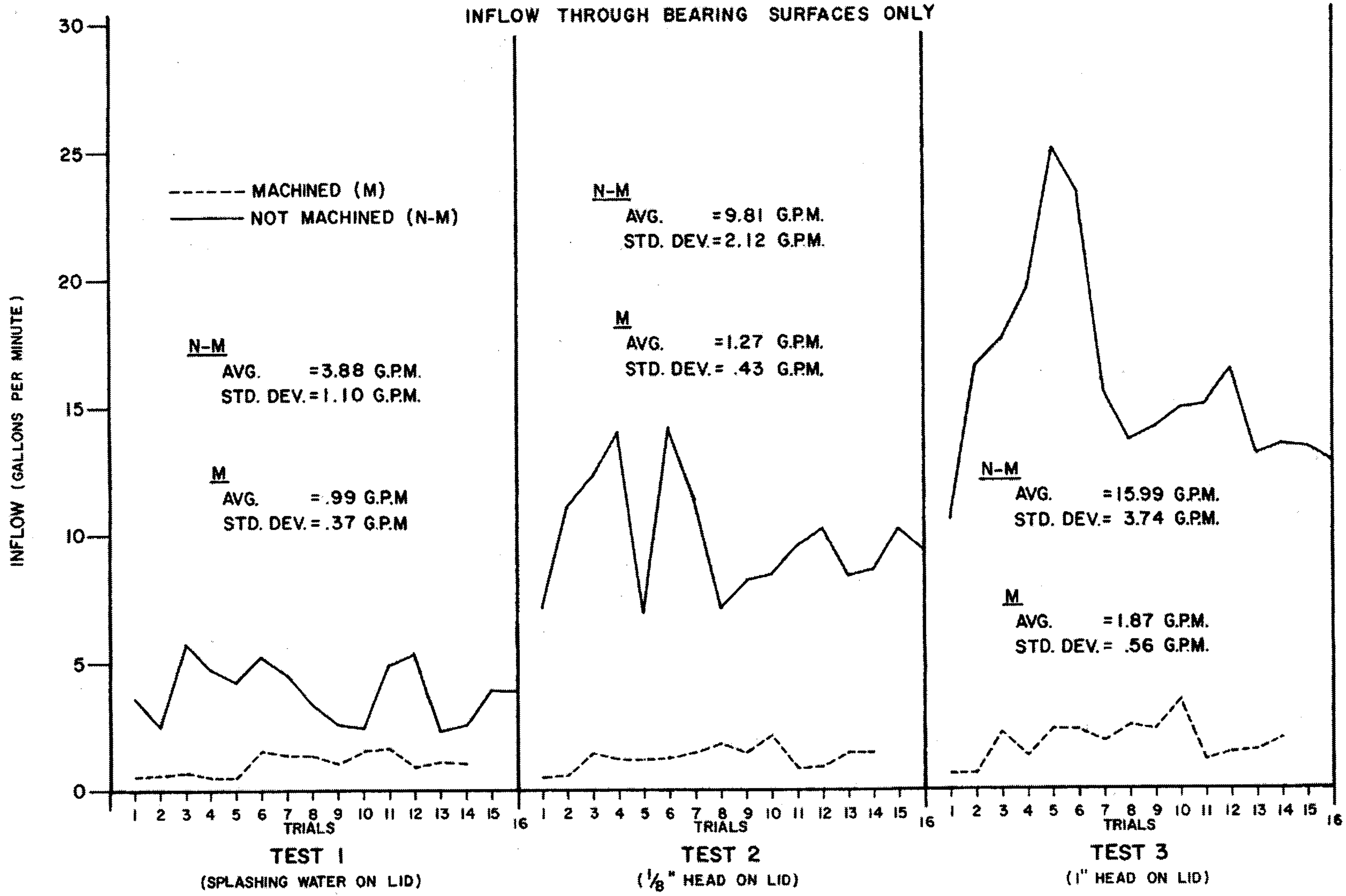


FIGURE 4

R 1040 WITH CONCEALED PICK HOLES, LID DIAMETER 23"

INFLOW THROUGH BEARING SURFACES ONLY

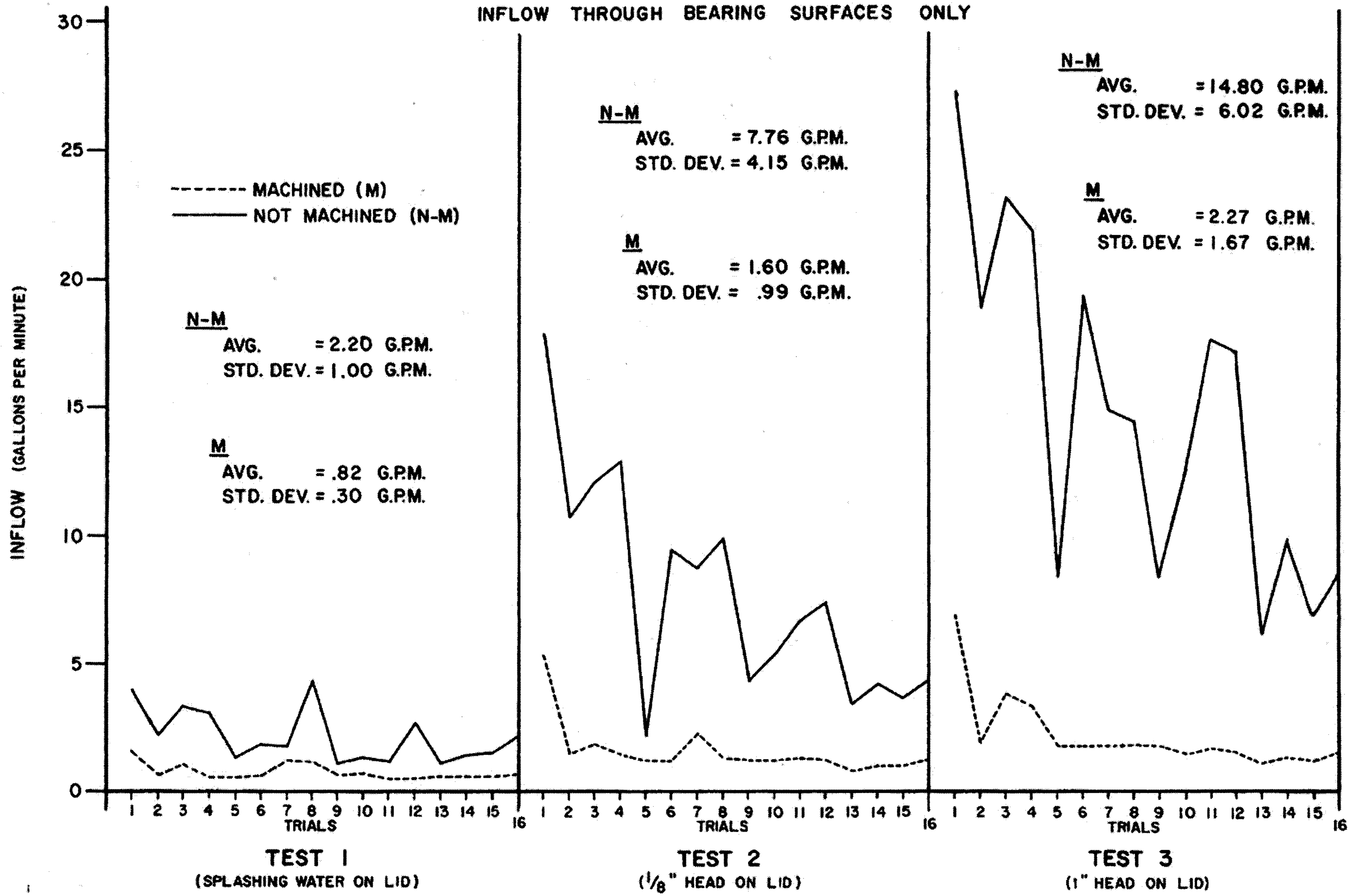


FIGURE 5

R 1670 WITH CONCEALED PICK HOLES, LID DIAMETER 24"

INFLOW THROUGH BEARING SURFACES ONLY

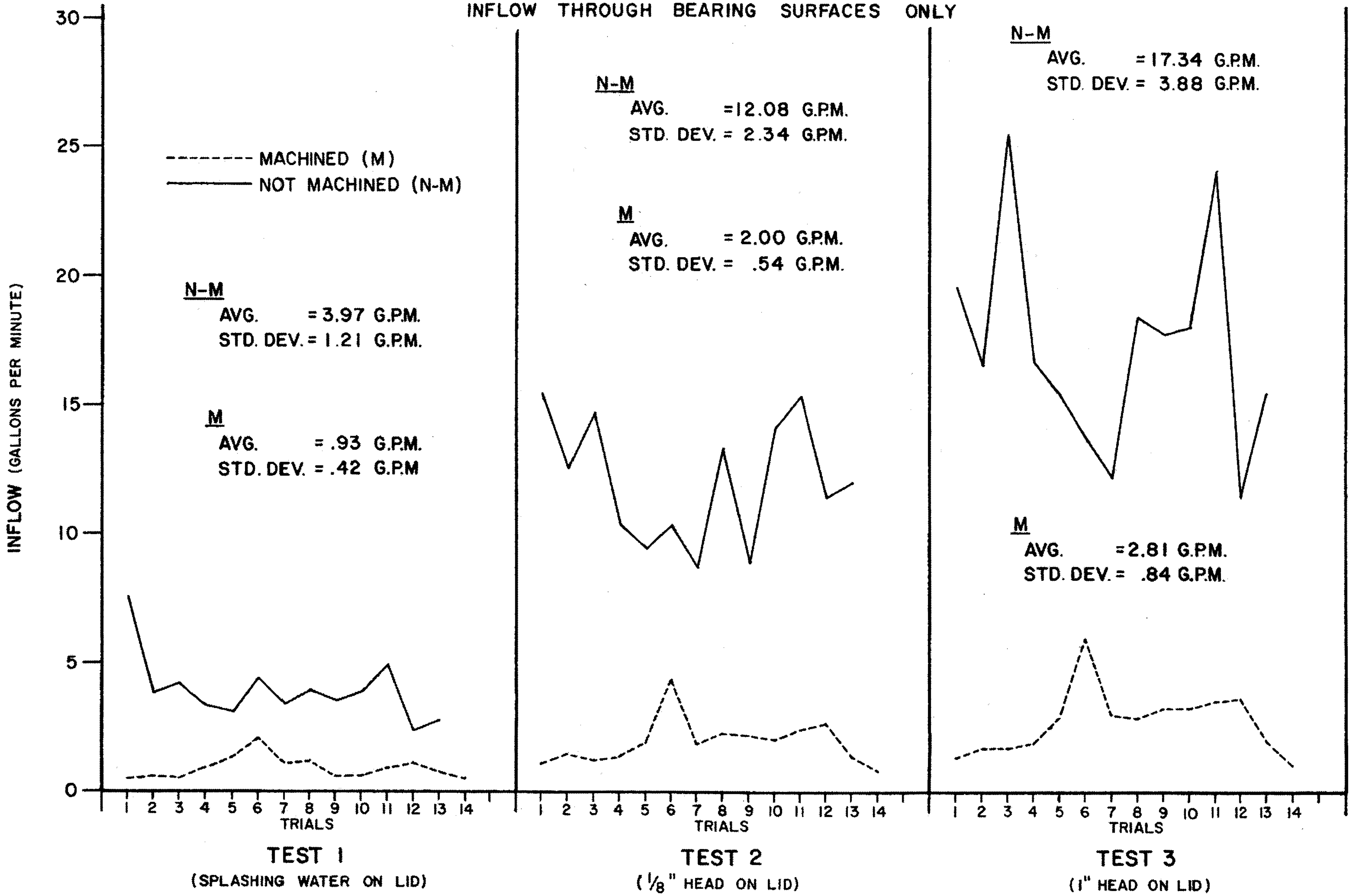


FIGURE 6

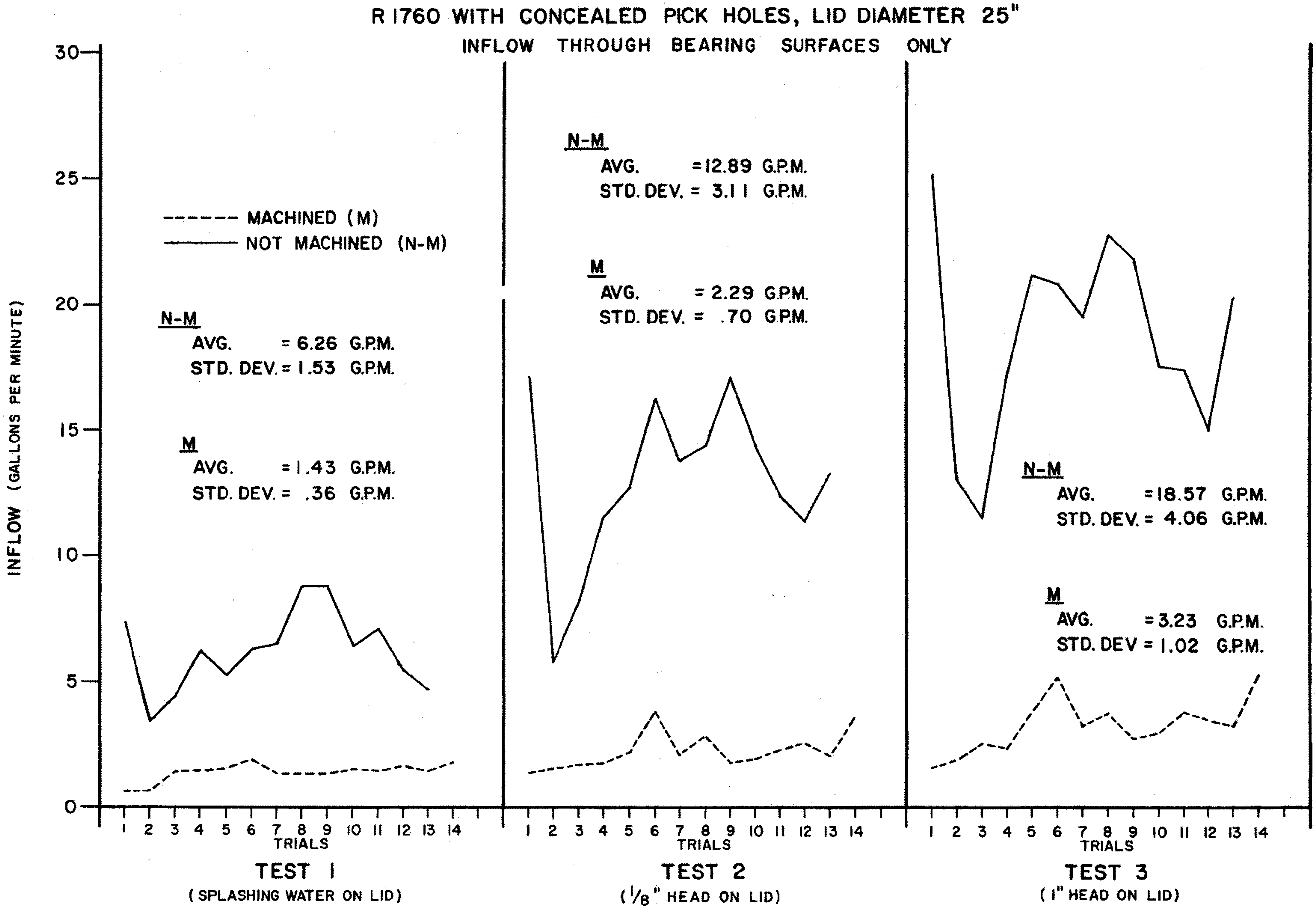

R 1760 WITH CONCEALED PICK HOLES, LID DIAMETER 25"
INFLOW THROUGH BEARING SURFACES ONLY
INFLOW (GALLONS PER MINUTE)
MACHINED (M)
NOT MACHINED (N-M)
N-M
AVG. = 6.26 G.P.M.
STD. DEV. = 1.53 G.P.M.
M
AVG. = 1.43 G.P.M.
STD. DEV. = .36 G.P.M.
N-M
AVG. = 12.89 G.P.M.
STD. DEV. = 3.11 G.P.M.
M
AVG. = 2.29 G.P.M.
STD. DEV. = .70 G.P.M.
N-M
AVG. = 18.57 G.P.M.
STD. DEV. = 4.06 G.P.M.
M
AVG. = 3.23 G.P.M.
STD. DEV = 1.02 G.P.M.
TRIALS
TEST 1
(SPLASHING WATER ON LID)
TEST 2
(1/8" HEAD ON LID)
TEST 3
(1" HEAD ON LID)

FIGURE 7

R 1642 WITH CONCEALED PICK HOLES, LID DIAMETER 26"

INFLOW THROUGH BEARING SURFACES ONLY

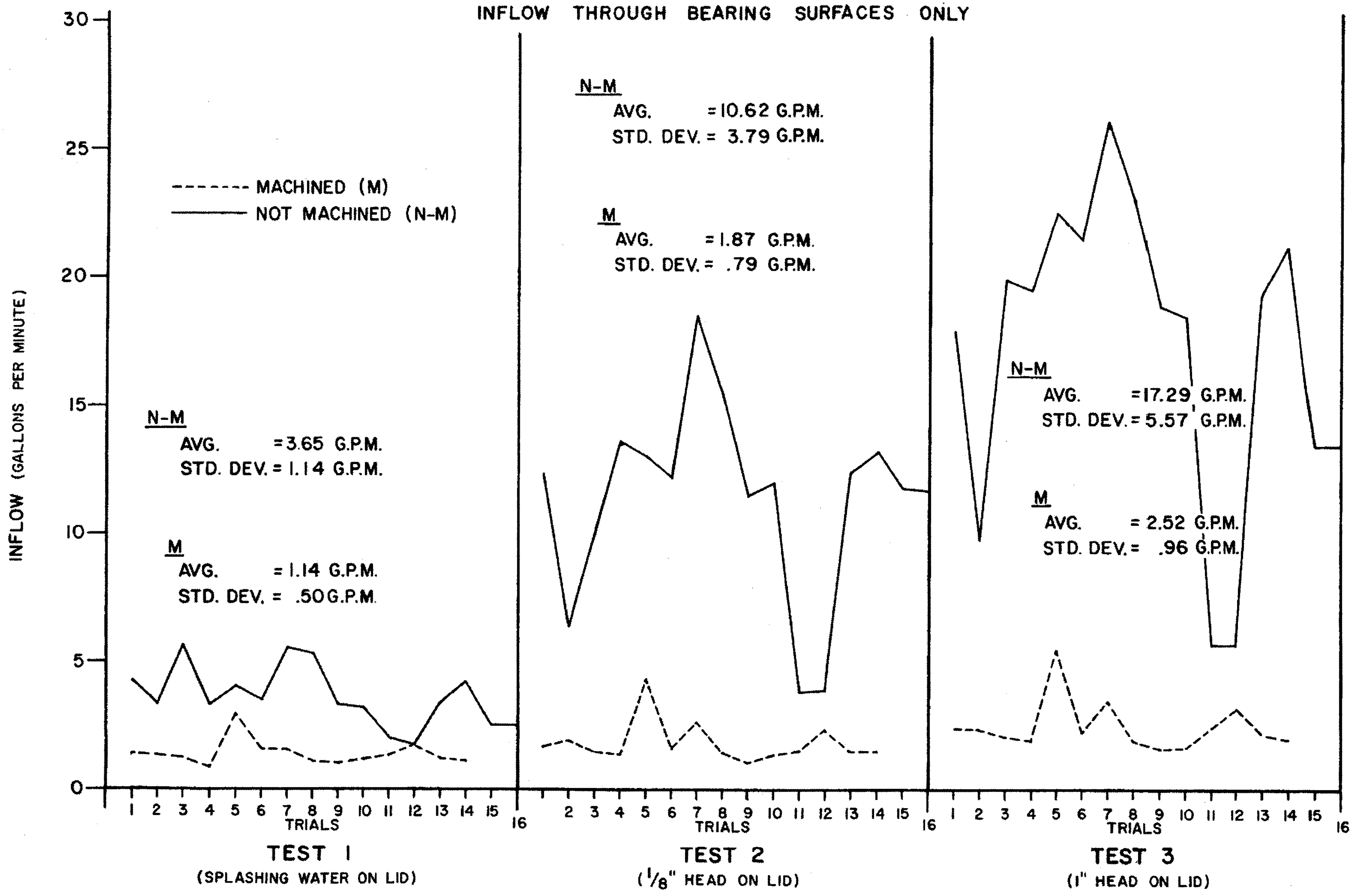
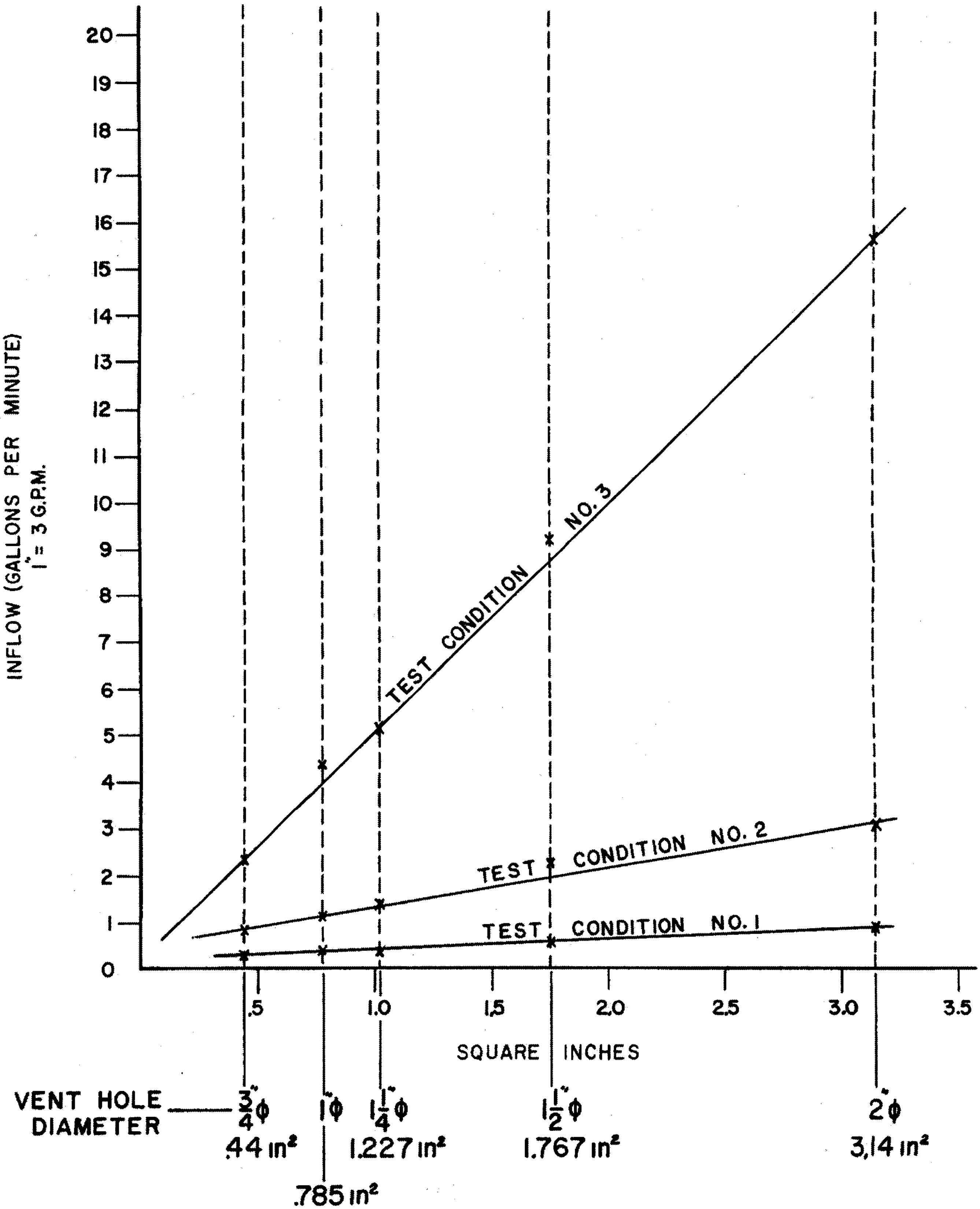


FIGURE 8

VENT HOLE/PICK HOLE INFLOW



CONCLUSIONS

It has been demonstrated as a result of this study that significant amounts of surface runoff water can enter a sanitary sewer system through vent holes, open pickholes and the apparently invisible space which exists at the contact (bearing) surfaces between manhole frames and lids. The amount of inflow will vary depending on the runoff (waterhead), manhole cover circumference, the degree of machining of the bearing surfaces, and on the amount of open area provided by pickholes and ventholes.

The results from the machined bearing surface tests indicate a proper fit between frame and lid is important for reducing inflow. This leads one to conclude that extra care should be taken by maintenance personnel to ensure that bearing surfaces be given a thorough dusting to remove any foreign material which would open the joints between manhole frame and lid and allow inflow.

The main criteria for determining if a manhole lid is a significant contributor to the inflow problem of the community, should be whether or not the manhole is subject to surface runoff and not simply how many holes it has in its cover. This is obviously important for two reasons.

1. Without water reaching the manhole, there would be no inflow.

And,

2. As the bearing surface tests have revealed, even manholes without any holes can allow significant amounts of inflow to enter through the bearing surface alone.

It is felt that for those systems in which inflow is a significant problem, manholes located in run off areas should be one of the first areas of the system to be investigated for the identification of inflow sources cost-effective for removal from the system. Neenah Foundry Company has developed a new, "Self-Sealing" replacement lid containing a simple, built-in gasket sealing system and concealed pickholes. This lid, subjected to the tests as described in this report, is virtually watertight. (Figure No. 9). Providing the existing manhole frame is in serviceable condition, these "Self-Sealing" lids can be manufactured to fit any frame at a very minimal expense.

No attempt has been made to introduce debris such as sand, leaves, paper, gravel, etc. into either the test water or manhole frames and lids, since it would be virtually impossible to set up test standards for these variables. It is felt that this material could just as well seal the inflow source or worsen it by expanding the bearing surface gap. A point to consider is that a properly maintained system would have each manhole inspected and entered for cleaning purposes periodically throughout the year which would tend to maintain the manhole lids in a state more similar to the test data conditions.

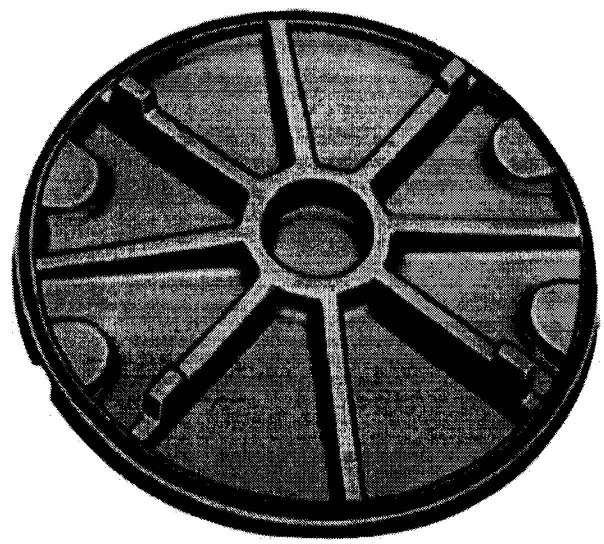


Figure 9. Neenah Self-Sealing Lid
Pat. No. 4,101,236

RECOMMENDATIONS

There are many ways to use the data in this report so as to arrive at the quantity of inflow a community's manholes might allow. Although the empirical data from the testing is quite extensive, one must be cautious in its use because of recognized variations in field conditions. What this report has hopefully done, is to confirm for the reader, that even manholes located in marginal runoff areas can experience significant amounts of inflow through the lids.

The key recommendation then is to first **locate those manholes subject to runoff** and then use this report data or a version thereof to evaluate the inflow contribution to the system. Those lids which are identified as significant inflow contributors can then be economically and effectively replaced with the Neenah "Self-Sealing" type lids,

APPENDIX A

DEFINITIONS*

Infiltration -
The water entering: a sewer system and service connections from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections or manhole walls. Infiltration does not include, and is distinguished from, inflow.

Inflow -
The water discharged into a sewer system and service connections from such sources as, but not limited to roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross connections from storm sewers and combined sewers, catch basins, storm water, surface runoff, street washes or drainage. Inflow does not include, and is distinguished from, infiltration.

Infiltration/Inflow-
The total quantity of water from both infiltration and inflow without distinguishing the source

Excessive infiltration/inflow –
The quantities of infiltration/inflow which can be economically eliminated from a sewer system by rehabilitation, as determined by a cost-effectiveness analysis that compares the costs for transportation and treatment of the infiltration/inflow subject to the provisions in Section 35.927.

*As defined in the Title 40 Rules and Regulations and published in the Federal Register, Section 35.905, Volume 39, Number 29, February 11, 1974.

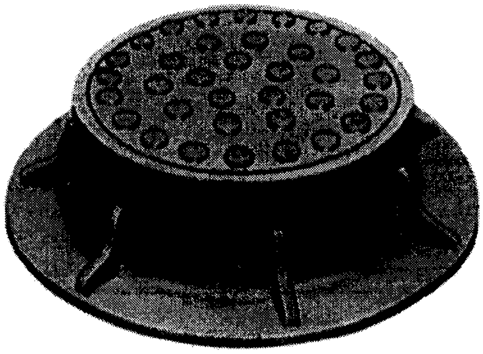
APPENDIX B

Examples of Manhole Lid Inflow

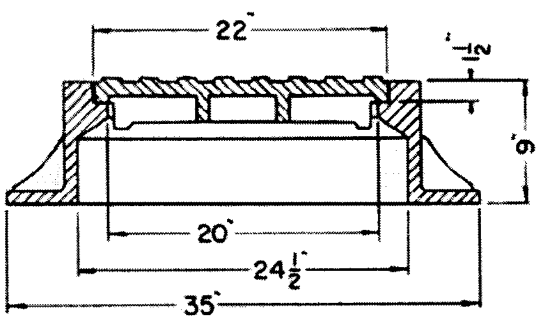
Copies of slides showing actual manhole lid inflow.

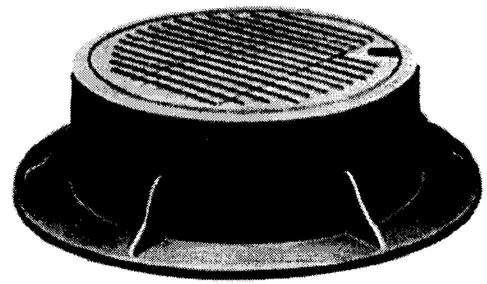
APPENDIX C

ILLUSTRATIONS AND DETAILS OF MANHOLE FRAMES AND LIDS TESTED WITH MACHINED AND NON-MACHINED BEARING SURFACES

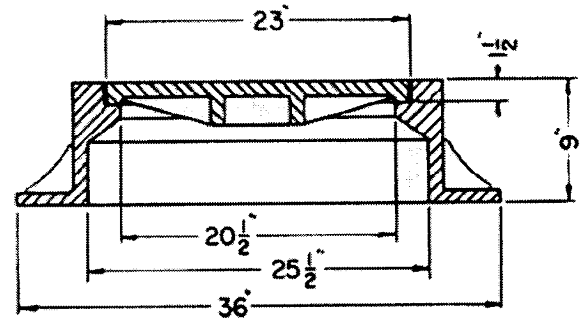


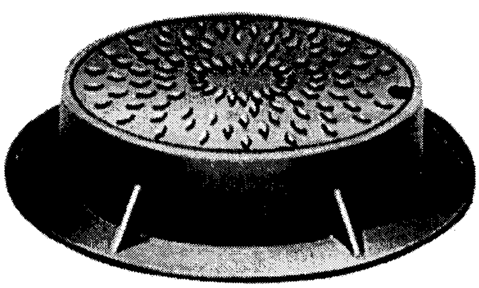
R-1090



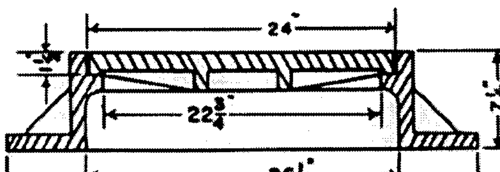


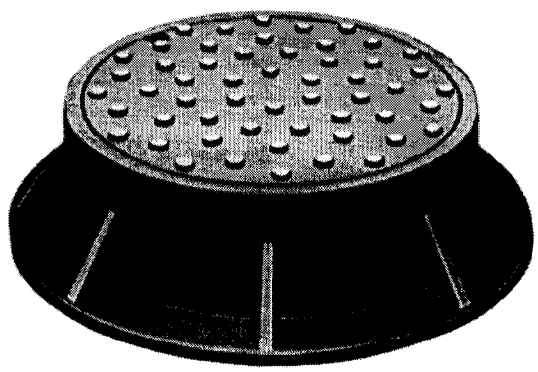
R-1040



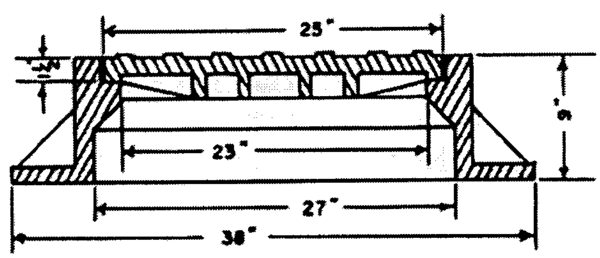


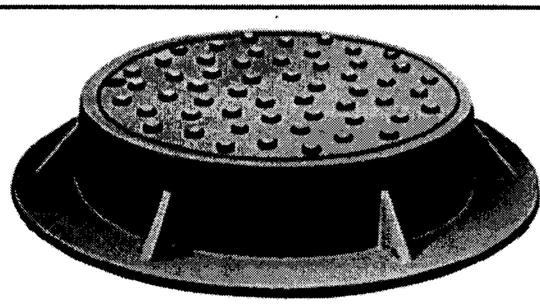
R-1670



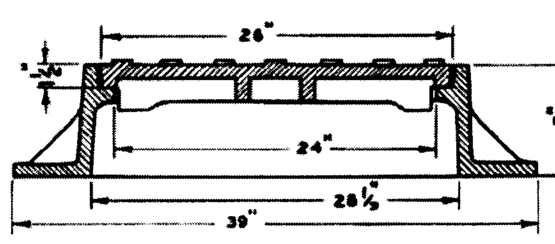


R-1760





R-1642



APPENDIX D

Tables Showing Inflow in GPM through Bearing Surfaces Only

(Data Points are Averages of Over 2000 Separate Tests)

High Values are Bold Face
Low Values are Bold Face ***Italic***
– No Test

Manhole Casting Size — R-1090, Lid Circumference 69.1"

	Ground Bearing (Not Machined)			Machined Bearing		
Trial	**Test 1**	**Test 2**	**Test 3**	**Test 1**	**Test 2**	**Test 3**
1	3.67	7.11	***10.60***	***.47***	***.47***	***.64***
2	2.52	11.03	16.69	.60	.64	.67
3	**5.74**	12.30	17.70	.75	1.46	2.20
4	4.74	14.00	19.96	.59	1.14	1.29
5	4.18	***6.89***	**25.04**	.59	1.11	2.38
6	5.16	**14.20**	23.31	**1.61**	1.22	2.31
7	4.59	11.35	15.53	1.41	1.51	1.96
8	3.39	7.09	13.72	1.42	1.88	2.53
9	2.67	8.13	14.17	1.02	1.49	2.31
10	2.45	8.47	14.96	1.58	**2.10**	**3.59**
11	4.93	9.52	15.04	.77	.91	1.11
12	5.33	10.20	16.45	.94	.99	1.54
13	***2.30***	8.38	13.06	1.09	1.44	1.61
14	2.62	8.77	13.53	1.02	1.44	2.00
15	3.94	10.13	13.42	–	–	–
16	3.91	9.41	12.86	–	–	–

Manhole Casting Size — R-1040, Lid Circumference 72.3"

1	4.09	**17.95**	**27.34**	**1.68**	**5.33**	**7.95**
2	2.24	10.81	18.96	.70	1.54	1.98
3	3.33	12.18	23.25	1.04	1.91	3.87
4	3.10	12.96	21.92	.56	1.57	3.33
5	1.41	***2.28***	8.92	.87	1.31	2.18
6	1.93	9.51	19.38	.52	1.26	1.79
7	1.78	8.77	14.92	.69	1.22	1.74
8	**4.34**	9.94	14.40	1.26	2.30	1.78
9	***1.11***	4.38	8.47	1.19	1.39	1.85
10	1.41	5.42	12.64	.70	1.22	1.83
11	1.26	6.78	17.79	.82	1.24	1.59
12	2.77	7.40	17.27	.57	1.34	1.74
13	1.14	3.49	***6.19***	***.50***	1.22	1.58
14	1.54	4.24	9.93	.67	***.89***	***1.17***
15	1.68	3.76	6.92	.65	1.01	1.39
16	2.13	4.31	8.50	.67	1.02	1.29
17	–	–	–	.79	1.27	1.54

High Values are Bold Face
Low Values are Bold Face ***Italic***
– No Test

APPENDIX D (Continued)

Manhole Casting Size — R-1670, **Lid Circumference** 75.4"

Trial	Ground Bearing (**Not** Machined) Test 1	Test 2	Test 3	Machined Bearing Test 1	Test 2	Test 3
1	**7.61**	**15.46**	19.66	***.44***	1.17	1.42
2	3.79	12.63	16.69	.64	1.57	1.81
3	4.21	14.76	**25.29**	.57	1.22	1.81
4	3.39	10.03	16.71	.96	1.44	1.99
5	3.09	9.49	15.48	1.29	1.99	2.93
6	4.43	10.41	13.78	**2.10**	**4.39**	**6.00**
7	3.44	***8.77***	12.21	1.14	1.93	3.05
8	3.99	13.35	18.53	1.27	2.33	2.97
9	3.57	8.95	17.84	.65	2.25	3.32
10	3.92	14.19	18.03	.74	2.08	3.39
11	4.92	15.43	24.05	.94	2.50	3.61
12	***2.38***	11.59	***11.59***	1.14	2.75	3.81
13	2.82	12.01	15.56	.84	1.53	2.03
14	–	–	–	.54	***.86***	***1.17***

Manhole Casting Size — R-1760, **Lid Circumference** 78.5"

Trial	Ground Bearing (**Not** Machined) Test 1	Test 2	Test 3	Machined Bearing Test 1	Test 2	Test 3
1	7.35	**17.11**	**25.16**	***.61***	***1.41***	***1.68***
2	***3.45***	***5.84***	11.99	.71	1.66	1.94
3	4.46	8.17	***10.46***	1.38	1.78	2.60
4	6.27	11.54	17.32	1.48	1.85	2.38
5	5.35	12.76	21.18	1.59	2.48	3.82
6	6.32	16.22	20.88	**1.96**	**3.86**	5.18
7	6.57	13.82	19.49	1.39	2.03	3.20
8	8.87	14.35	22.81	1.33	2.88	3.81
9	**8.89**	17.04	21.88	1.38	1.79	2.78
10	6.47	13.38	17.66	1.61	1.98	2.99
11	7.09	12.31	17.30	1.53	2.28	2.78
	5.52	11.37	14.99	1.71	2.62	3.57
13	4.78	13.25	20.31	1.41	2.02	3.05
14	–		–	1.86	3.66	**5.30**

Manhole Casting Size — R-1642, **Lid Circumference** 81.7"

Trial	Ground Bearing (**Not** Machined) Test 1	Test 2	Test 3	Machined Bearing Test 1	Test 2	Test 3
1	4.29	12.34	17.95	1.40	1.71	2.40
2	3.30	6.39	9.74	1.30	1.95	2.30
3	**5.77**	10.06	19.93	1.19	1.49	2.06
4	3.35	13.66	19.50	***.94***	1.38	1.95
5	4.01	13.01	22.61	**2.99**	**4.34**	**5.45**
6	3.62	12.14	21.53	1.63	1.68	2.20
7	5.63	**18.50**	**26.04**	1.64	2.66	3.57
8	5.27	15.51	23.09	1.07	1.46	1.95
9	3.29	11.50	18.87	1.02	***1.07***	***1.61***
10	3.19	12.00	18.40	1.16	1.39	1.76
11	2.01	***3.82***	***5.70***	1.39	1.63	2.50
12	***1.79***	3.94	5.74	1.85	2.35	3.25
13	3.39	12.38	19.47	1.21	1.54	2.23
14	4.21	13.20	21.18	1.14	1.54	2.00
15	2.68	11.76	13.43	–	–	–
16	2.60	11.64	13.45	–		

APPENDIX E

Raw Test Data for Vent/Pickhole Inflow

Table values shown are water depths in feet as measured in the receiving tank for each trial. Tests lasted one minute. By averaging the ten test trials in each column and multiplying this result by tank factor 33.5431 GPM per foot of depth, the average GPM for each hole diameter is obtained.

Test No. 1

Hole Diameter

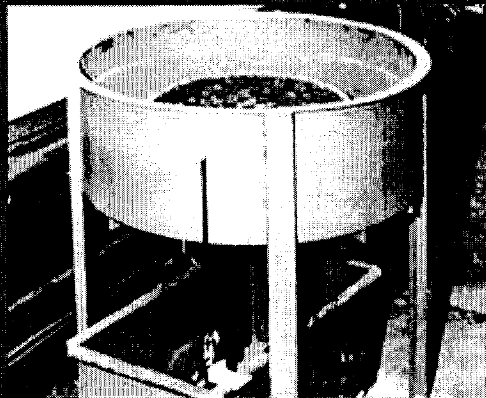
Trial	¾"	1"	1¼"	1½"	2"
1	.007	.010	.014	.019	.029
2	.008	.012	.013	.017	.027
3	.007	.011	.013	.019	.026
4	.008	.009	.015	.018	.030
5	.007	.013	.014	.018	.025
6	.008	.011	.014	.018	.027
7	.007	.010	.013	.017	.027
8	.008	.012	.014	.019	.025
9	.008	.011	.015	.017	.029
10	.008	.011	.013	.017	.027
Ave. GPM	.354	.365	.462	.600	.912

Test No. 2

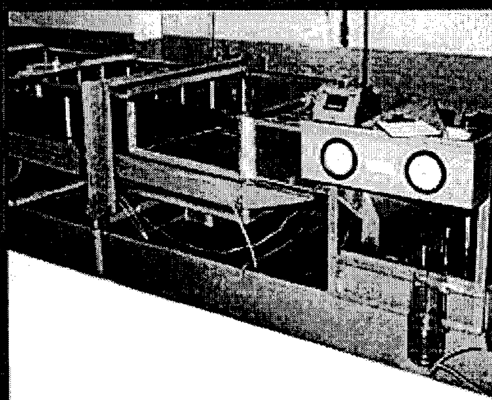
1	.023	.032	.044	.066	.098
2	.026	.036	.043	.072	.095
3	.023	.034	.047	.069	.094
4	.026	.035	.045	.071	.097
5	.022	.034	.046	.067	.092
6	.026	.038	.046	.072	.089
7	.025	.032	.043	.066	.091
8	.025	.037	.044	.070	.091
9	.024	.033	.048	.069	.097
10	.026	.033	.048	.071	.094
Ave. GPM	.224	1.153	1.522	2.324	3.145

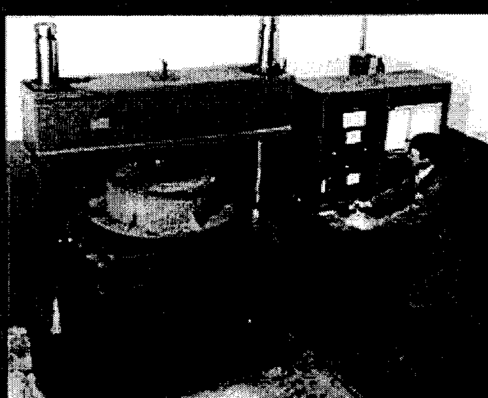
Test No. 3

1	.071	.132	.186	.276	.463
2	.074	.133	.180	.277	.469
3	.072	.131	.187	.275	.467
4	.074	.127	.185	.277	.465
5	.071	.127	.186	.272	.468
6	.071	.129	.181	.276	.466
7	.072	.128	.178	.276	.460
8	.074	.132	.182	.277	.462
9	.071	.130	.185	.275	.467
10	.073	.133	.187	.375	.467
Ave. GPM	2.424	4.366	6.161	9.243	15.609



OVER 100 YEARS OF LEADERSHIP IN THE INDUSTRY





NEENAH

FOUNDRY COMPANY